PATENT SPECIFICATION (11) 1 415 539

1 415 539

(21) Application No. 58649/72 (22) Filed 19 Dec. 1972 (19)
(23) Complete Specification filed 7 Feb. 1974
(44) Complete Specification published 26 Nov. 1975
(51) INT. CL.[2] F02M 61/16 F23D 11/34
(52) Index at acceptance
F1B 2H 2J15AX 2J15B1 2J1B7
B2F 10D1C 10F1A 10F1EY 10F2A 15A1C 15A2B 2X
F4T A2B2 A2E

(72) Inventor NORMAN MOSS

(54) A LIQUID INJECTION SYSTEM

(71) We, THE PLESSEY COMPANY LIMITED, a British Company of 2/60 Vicarage Lane, Ilford, Essex, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a liquid injection system which may be used for example, for injecting fuel into an engine such for example as an internal combustion engine, a gas turbine engine or a boiler.

In liquid injection systems, it is often desirable that the liquid injected be in an atomized condition. Some injection systems employ a vibratory injection nozzle for generating a liquid spray but the injected liquid may not always be entirely atomized and a liquid core may be present in the injected liquid. In the case of fuel injection systems, non-atomized fuel is not effectively carried to the combustion chamber of the engine and is often wasted, thereby resulting in a high fuel consumption.

The present invention provides a liquid injection system comprising a liquid injection nozzle and a vibrator for the nozzle, said nozzle having a non-return valve, a liquid swirl device positioned downstream of the non-return valve and in a swirl chamber, and an atomizer orifice positioned downstream of the swirl chamber, and said vibrator being for vibrating the nozzle at least sufficiently to open the non-return valve and allow liquid to move into the swirl chamber and swirl therein prior to passing through the atomizer orifice.

The swirling of the liquid in the swirl chamber prior to the liquid leaving the atomizer orifice increases the ability of the nozzle to atomize the liquid. If the liquid pressure is sufficiently high and an appropriately contoured atomizer orifice is used, effective atomization may be achieved merely by vibrating the nozzle at frequencies which are only just sufficient to open the non-return valve. At low liquid pressures, the liquid may not sufficiently atomize as it leaves the nozzle and, in this case, the nozzle may be vibrated with so-called ultrasonic vibrations. When the nozzle is vibrated with ultrasonic vibrations, the vibrations will act to open the non-return valve and they will also act to cause atomization.

The "ultrasonic vibrations" are those vibrations required of the liquid injection nozzle to cause the non-return valve to open and to also cause atomization. The vibrations are sufficient to cause a liquid jet to disintegrate into small mist-like particles. The frequency range in question may be in practice found to have its lower limit somewhere near the upper limit of audibility to a human ear. However, for reasons of noise suppression, it is generally preferable in practice to use frequencies high enough to ensure that audible sound is not produced.

Preferably, the non-return valve is a ball valve but other types of non-return valve may be employed if desired. Thus, for example, a leaf-type non-return valve could be employed. Also preferably, the non-return valve is biassed, e.g. by means of a spring, to the closed position. The vibrations of the nozzle then cause the ball valve to be lifted from its seat against the force of the biassing means.

In order to further facilitate optimum atomization of liquid leaving the nozzle, the atomizer orifice is preferably contoured such that it is constituted by a passage opening out into a sharp-edged frusto-conical opening having its narrower part in communication with the passage.

The swirl device may be any form of plug that causes the liquid to swirl. Preferably, the swirl device is an externally helically grooved plug and the liquid is caused to swirl by passing along the grooves

in the plug. As the liquid leaves the plug, it continues the swirling motion imparted by the helical grooves. The swirl device may be secured in the nozzle by any convenient means such for example as welding. The swirl device may be so constructed as to deliver liquid in continuous form or in large droplets substantially tangentially to the walls of the swirl chamber.

The injection system of the present invention lends itself readily to variation in the type of liquid injected. When the injection system is for application to engines, it may be used to inject fuel in the form of petrol, oil or a mixture of petrol and oil. The quantity of fuel injected during each induction stroke in each cylinder or each revolution of an internal combustion engine may be varied. By ensuring efficient atomization of the injected fuel, the fuel injection is less dependent upon air pressure for example in an air flow duct leading to the combustion chamber of the engine.

The injection system may include a liquid feed device for providing a flow of liquid to the nozzle. The injection system may also include a timing control device which limits the energization of the nozzle vibrations to uniformly spaced periods. Each timing period may constitute an adjustable part of a cycle related to the revolution of an engine. The timing control device may be so connected to an engine as to limit energization of the ultrasonic vibrator to an adjustable part of each induction stroke in each cylinder.

The vibrator may be a known transducer assembly. It may employ a piezoelectric crystal, for example a barium titanate crystal.

An embodiment of the invention will now be described by way of example with reference to the single Figure of the accompanying drawing which shows an injection nozzle forming part of a fuel injection system in accordance with the present invention.

Referring to the drawing, there is shown a fuel injection nozzle 2 having an inwardly projecting shoulder 4. The shoulder 4 defines an aperture 6 and constitutes a valve seat against which rests a non-return ball valve 8. The ball valve 8 is spring biassed against the valve seat by means of a coil spring 10.

Positioned in the fuel injection nozzle 2 at a place downstream of the ball valve 8, is a fuel swirl device constituted by a plug 12 having helical grooves 14 arranged in its external surface. Downstream of the fuel swirl device 12 is an atomizer orifice 16 having a passage 18 merging into a sharp-edged frusto-conical opening 20. The sharp edges of the frusto-conical opening 20 help to facilitate good fuel atomization as the fuel leaves the nozzle.

In operation of the device, the fuel injection nozzle 2 is vibrated by an ultrasonic transducer assembly (not shown). The vibrations are sufficient to lift the ball valve 8 oc its seat but they are not sufficient *per se* to also atomize the fuel although the vibrations may of course assist in fuel atomization. Fuel can then pass along a conduit 22 through the aperture 6 and into a swirl chamber 24. The fuel passing through the aperture 6 will usually be continuous or but, with ultrasonic vibrations, may be discontinuous but in the form of very large droplets. The fuel will then pass along the grooves 14 in the fuel swirl device 12 where it will be given a swirling motion. The swirling fuel will continue to swirl in the downstream side of the swirl chamber 24. This swirling action will be further continued as the fuel passes through the atomizer orifice 16 so that not all of the fuel emitted from the atomizer orifice 16 will be perpendicular to the front face 26 of the nozzle. Efficient fuel atomization is thus achieved.

WHAT WE CLAIM IS:—

1. A liquid injection system comprising a liquid injection nozzle and a vibrator for the nozzle, said nozzle having a non-return valve, a liquid swirl device positioned downstream of the non-return valve and in a swirl chamber, and an atomizer orifice positioned downstream of the swirl chamber, and said vibrator being for vibrating the nozzle at least sufficiently to open the non-return valve and allow liquid to move into the swirl chamber and swirl therein prior to passing through the atomizer orifice.

2. A system according to claim 1, in which the vibrator is for vibrating the nozzle at ultrasonic frequency as herein defined.

3. A system according to claim 1 or claim 2, in which the non-return valve is a ball valve.

4. A system according to claim 3, in which the ball valve is biassed to a closed position by means of a spring.

5. A system according to any one of the preceding claims, in which the atomizer orifice is constituted by a passage opening out into a sharp-edged frusto-conical opening having its narrower part in communication with the passage.

6. A system according to any one of the preceding claims in which the swirl device is an externally helically grooved plug.

7. A system according to any one of the preceding claims, including a liquid feed device for providing a flow of liquid to the nozzle.

8. A system according to any one of the

preceding claims including a timing control device which limits the energization of the nozzle vibrations to uniformly spaced periods.

9. A system according to any one of the preceding claims in which the vibrator includes a piezoelectric crystal.

10. A fuel injection system substantially as herein described with reference to the accompanying drawing.

C. H. JONES,
Chartered Patent Agent,
For the Applicants.

Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1975.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY
from which copies may be obtained.

[illegible] COMPLETE SPECIFICATION

1 SHEET This drawing is a reproduction of the Original on a reduced scale